its long aftermath, they have believed that in the seventeenth century there were only two options for a philosophy of space, either substantivalist or relationist—as if Schoolmen and *novatores* alike had not advanced a plethora of other theories of imaginary or abstract spaces. Accordingly, Leibniz's dismissal of a substantial space in 1672 has unwarrantedly been taken as the entry point for a relational theory. But in fact in the following sixteen years (1672–88) Leibniz was neither a substantivalist nor a relationist concerning space.[8]

Leibniz bears a fair share of responsibility for fostering such a misconception. In his later years, Leibniz presented his theory of space as an important piece of a more general view, in which space, time, and motion were conceived together as systems of relations. He tried to persuade his readers that these relational theories stand or fall together. They do not: many other thinkers endorsed theories of relational time and relational motion without ever supporting a theory of relational space. Leibniz did the same for many years. He accepted relationism about time and motion in the late 1670s, unemphatically taking sides with a majority of other philosophers of the same period. It was only in 1688 that Leibniz conceived relationism about space: a new theory that no one had dreamed before. Leibniz was well aware that this was a great novelty in metaphysics and aimed to support it by offering the 'harmonic' view of relational theories (space, time, and motion, all linked together) that he defended in his later years. Modern interpreters have been caught under the same spell and have believed that since Leibniz advocated relational theories of motion and time in the 1670s, he also supported a relational theory of space in the same years. Let's briefly look at these different theories.

From 1676, Leibniz endorsed a *relational theory of motion*.[9] Similar theories were defended by many philosophers and scientists in the seventeenth

[8] Among many others, this is especially clear in T. Crockett, 'Space and Time in Leibniz's Early Metaphysics' ['Space'], *The Leibniz Review*, 18 (2008), 41–79, who ascribes to Leibniz a relational theory of space in the 1680s, based on the fact that in those years Leibniz said that space is not real (54) but rather imaginary (50), and that time is an order (53).

[9] See A VI, 3, N. 6, 101–11, and note 76 below. Leibniz's views should not be equated with a theory of relative motion; see S. Puryear, 'Motion in Leibniz's Middle Years: A Compatibilist Approach', in Daniel Garber and Donald Rutherford (eds.), *Oxford Studies in Early Modern Philosophy, Volume VI* (Oxford: Oxford University Press, 2012), 135–70. A theory of *relational* motion claims that the motion of a body may only be defined in relation to other bodies; it is opposed to a theory of *absolute* motion, according to which motion may be defined as an individual (unary) property of each body. The latter theory may in turn be grounded on a theory of absolute space, but is not necessarily so. On the other hand, a theory of *relative* motion is opposed to a theory of *true* motion. According to the former, all motions are dependent on the

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century, such as Descartes and Huygens. None of them ever conceived of space as being made up of relations.[10] In fact, many modern theories of motion, including Leibniz's theory in the middle period, did not rely on any robust notion of space. A great deal of early modern physics was *spaceless* in ways that may seem astonishing to the modern interpreter.[11]

It was a novelty of *Newton*'s approach to natural philosophy to argue that a theory of motion—which according to him could be experimentally tested—entails a certain theory of space.[12] With this unprecedented claim, Newton opened the way to the modern understanding of the deep interrelation between space and motion in physics.[13] Reading the *Principia*, Leibniz

observer and the chosen system of reference; according to the latter, a difference may be spelled out between observer-independent ('true') and apparent motions. In 1676, Leibniz embraced relationism about motion, but he also expressed his concerns that relationism might act as a slippery slope towards relativism—a consequence that he was not ready to accept without qualifications. He attempted to prevent this outcome by defining true motion through the simplicity of hypotheses (A VI, 3, N. 6, 110–11). In 1678, Leibniz introduced a further metaphysical foundation of true motion and claimed that true motions are caused by forces. In any case, starting from the late 1670s Leibniz advocated a theory of relational but non-relative motion.

[10] An outstanding case is Thomas White's *Euclides physicus* (London: Crook, 1657), which advanced many philosophical arguments to the effect that motion is relational, including several that would be used by Leibniz in his exchange with Clarke (such as that if there was a single body in the universe, it could not move). White drew the consequence that space is not real but never claimed that space is relational: the latter thesis is entirely Leibniz's own. Leibniz read and annotated *Euclides physicus* in the summer of 1689, when he was developing his natural philosophy to oppose Newton's absolute space and motion, but after having conceived the idea of a relational space (see A VI, 4, N. 383, 2088–116).

[11] In Leibniz's physical works, space is generally only mentioned in the technical sense of an 'interval' in such expressions as 'equal times in equal spaces', etc. There are no references to a general background space, much less to the imaginary space of the middle period. This continued to happen in the later period: see below, note 131. This spaceless approach to physics demands special historical care when premodern science is interpreted through modern spectacles such as the spatial models of J. Earman, *World Enough and Space-Time* (Cambridge: MIT Press, 1989).

[12] The idea that motion is relative to space and not to bodies was, of course, much older than Newton, and in the seventeenth century it had been assessed by people like Mariotte, Pardies, and Borelli (see E. Slowik, *The Deep Metaphysics of Space* [*Space*] [Berlin: Springer 2016], 23–7). Newton, however, may have been the first to argue that the laws of motion *require* a reference to absolute space. Leibniz does not seem to have extensively commented on these other authors. Mariotte's physical work is not discussed in Leibniz's papers published so far. Pardies's treatise was discussed at length by Leibniz in 1672–3, i.e. when he was himself still advocating absolute motion, but Leibniz said nothing about the important passage in which Pardies distinguished between the speed of a body relative to space, which he called *vîtesse absoluë*, and the speed of a body relative to other bodies, or *vîtesse respective*. See I.-G. Pardies, *Discours du mouvement local* (Paris, Martin 1670), 44; Leibniz's remarks, skipping page 44, are in A VIII, 2, N. 47, 409. Finally, in 1687, just a few months before reading Newton's *Principia*, Leibniz equated Borelli's views on space to those of Lessius, Gassendi, Guericke, and More (see A VI, 4, N. 421, 2462), but he did not comment on them any further.

[13] Among Newton scholars, R. Rynasiewicz, 'By their properties, causes and effects: Newton's scholium on time, space, place and motion', *Studies in History and Philosophy of Science*, 26

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realized that since Newton had grounded a theory of absolute motion on absolute space, he had to devise a theory of relational space in order to overturn Newton's physics. This new theory of relational space was perfectly integrated with Leibniz's pre-existing theory of relational motion. Thus, Leibniz felt he needed to articulate a novel theory of space in 1688 because Newton's arguments had convinced him that a theory of motion could not stand without a matching theory of space, and in fact needed to be grounded on the latter. Leibniz eventually presented these two theories knotted together in his correspondence with Clarke, and they continued to be discussed together in the following tradition as if they were inseparable.

Something similar happened with Leibniz's *relational theory of time*, which was also publicly expounded in the Leibniz–Clarke correspondence. A relational theory of time had already been hinted at by Leibniz in some private *Definitiones cogitationesque metaphysicae* of 1678–80 (among other papers), in which he explained that we employ time to give an order to natural changes, so that time is a relation among things ('*hic rerum inter se respectus dicitur tempus*').[14] Therefore, in light of Leibniz's later statements, modern interpreters have assumed that in the same period Leibniz would also have endorsed a relational theory of space.

The definition of time as an order of things or an order of changes is, however, perfectly classical. Aristotle had famously defined time as the 'number of movement' and referred to it as an *order* (τάξις) of sorts.[15] In this respect, Leibniz's conception of time was quite standard.[16] In the early modern

(1995), 133–53 and 295–321, has claimed that Newton's Scholium to the Definitions in the *Principia* aimed to prove that motion is absolute (i.e. a unary property), under the assumption (accepted by many, and Leibniz among them) that motion is real. Newton's Scholium further argued that absolute motion may only be described by assuming absolute space. Clarke quoted Newton's Scholium on absolute space in §13 of the Fourth Reply (Robinet, *Leibniz–Clarke*, 111), to which Leibniz replied that he saw nothing in it that could prove the reality of space (Fifth Letter, §53; Robinet, *Leibniz–Clarke*, 149). On the role of experimental philosophy in this connection, see the important A. E. Shapiro, 'Newton's "Experimental Philosophy"', *Early Science and Medicine*, 9 (2004), 185–217.

[14] A VI, 4, N. 267, 1397. Cf. also Leibniz's Aristotelian definition of time in his correspondence with Thomasius: 'Tempus nihil aliud est quam magnitudo motus' (Leibniz to Thomasius, 20/30 April 1669; A II, 1, N. 11, 34).

[15] For Aristotle's famous definition of time, see *Phys.* Γ 4, 219^{a}30-^{b}8. For the role of τάξις, see *Cat.* 6, 5^{a}24–32.

[16] This is not to say, of course, that Leibniz's overall theory of time was standard in the seventeenth century. On the contrary, it was highly refined and highly personal, encompassing a causal theory of time (of sorts) and further subtleties on continuity and change. A masterful presentation of it is offered in Arthur, *Leibniz*.

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period, many philosophers agreed that time was an order among things or events; but none of them believed that space was an order as well.

It should be remarked that when, in his later years, Leibniz stated that space is an order of coexistence and time an order of succession, these two claims were not for him on the same footing. Quite often, Leibniz did not say that *both* space and time are orders but that space, *just like time*, is an order. He was certain that his reader would have accepted the claim concerning time and stressed that this was the case with space as well—which was Leibniz's own, unprecedented theory.[17]

Once again, it was one of Newton's achievements to show that a physical theory required a uniform treatment of space and time (as two 'absolute' beings, according to him). It is therefore possible that Leibniz was pushed to envisage a theory of space on the blueprint of the theory of time from his reading of the *Principia*. When, later on, Leibniz highlighted the analogy between space and time, he had accepted and at the same time turned upside down Newton's views.

Finally, I highlight a third conceptual red herring in dating Leibniz's theory of space. From around 1677, Leibniz developed a *geometria situs*, that is, a new mathematical discipline that would supersede classical geometry by studying the basic spatial relation of *situation*. Since Leibniz's late definition of space is that of an order of situations, this geometry is indeed the science of space. I have claimed elsewhere that Leibniz's studies on geometry powerfully contributed to his *later* philosophy of space. Leibniz employed the mathematical analysis of situation to explore the nature and properties of space as an order of situations, and his geometrical essays shed much light on his claims in the correspondence with Clarke.[18]

[17] See §4 of Leibniz's Third Letter to Clarke (Robinet, *Leibniz–Clarke*, 53). To give some further examples among many, see the letter to Remond of 26 March 1716, in which Leibniz refers to the correspondence with Clarke: 'Je luy envoyai dernierement une demonstration que l'Espace, qui est *idolum tribus* de plusieurs, comme parle Verulamius, n'est plus une substance, ny un etre absolu, mais un ordre comme le temps' (Robinet *Leibniz–Clarke*, 61–2; and GP III, 674; cf. also GP III, 612 and 622 in the same exchange). See also the notes on Des Bosses's letter of 12 December 1712: 'Spatium non magis est substantia quam tempus' (GP II, 473; also in B. Look and D. Rutherford (eds.), *The Leibniz–Des Bosses Correspondence* [*Des Bosses*] (New Haven: Yale University Press, 2007), 312); or the letter to Fardella of 1698 quoted in note 129.

[18] See V. De Risi, *Geometry and Monadology. Leibniz's* Analysis Situs *and Philosophy of Space* [*Geometry and Monadology*] (Basel/Boston: Birkhäuser, 2007). Leibniz's idea of space as an order of situations superseded the Neoplatonic inference that space is 'the source of quantity', mathematics is the science of quantity, and therefore mathematics is the science of space. In Leibniz's novel view, space was not primarily a quantity but, rather, a relational structure (which may *also* have a quantity), and geometry—still conceived as the science of space—became a science of structures (V. De Risi, *Leibniz on the Parallel Postulate and the Foundations of Geometry*

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Other interpreters, however, have inferred that as early as the late 1670s, when this new geometry of situations was blossoming, Leibniz had begun to conceive of space as an order of situations.[19] This inference is unwarranted. Nowhere in Leibniz's studies of *geometria situs* of the 1670s and 1680s is space defined as an order of situations. Instead, in these texts space (and sometimes 'absolute space') is standardly defined as an *extensum*, an extended thing, and situation as a *positio in extensione*. Situational relations are relations *in space*, and space is their condition of possibility.[20] In short, Leibniz regarded space not so much as an abstract order of situations but, rather, as the concrete, extended background in which situational relations obtain.[21]

This view of situational relations was commonplace at the time, and Newton, for one, also accepted that in absolute space one may mark out situational relations between points or between bodies.[22] But space, for both Newton and Leibniz in the middle period, was not *reducible* to this situational order. This reduction happened, for Leibniz, in 1688. At this time, Leibniz realized that he did not need an underlying spatial extension grounding the system of situational relations, and that this system itself was enough to define space and to do geometry. Leibniz's theory of space changed accordingly.

[*Leibniz on Parallels*] [Basel/Boston: Birkhäuser, 2015]). Newton could not follow Leibniz on this path; on Newton's philosophy of mathematics, see N. Guicciardini, *Isaac Newton on Mathematical Certainty and Method* (Cambridge: MIT Press, 2009).

[19] See especially R. T. W. Arthur, 'Leibniz's Theory of Space' ['Leibniz's Space'], *Foundations of Science*, 18 (2013), 499–528, and Arthur, *Leibniz*. Richard Arthur's contributions on Leibniz's philosophy of space are very insightful since he is among the few interpreters to have connected Leibniz's theory of space with his geometry of situation.

[20] For a characterization of situation as a position in extension, see the *Enumeratio terminorum simpliciorum*, from around 1684, in A VI, 4, N. 97, 391. A similar instance can be found in several texts in which position and situation are defined as properties of what is in, or may be perceived in, an extended thing (cf. *Demonstratio axiomatum Euclidis*, 1679, in A VI, 4, N. 54, 176). In the *Enumeratio*, a characterization of *situs* as a 'mode of coexistence' (*coexistendi modus*) also appears—possibly for the first time. This would later evolve into a mode of coexistence (situation) embedded in an order of coexistence (space). The latter definition is, however, missing in the 1684 text, where space is still regarded as an *extensum* (i.e. a coexistent *continuum*). In *De magnitudine* of 1676, Leibniz explicitly regarded space as the condition of situation: 'secundum spatium res concipimus sitas' (A VI, 3, N. 64, 484). In the *Generales Inquisitiones* (1686), 'having *situs*' is equated to 'existing in space' (A VI, 4, N. 165, 745).

[21] In the mid-1680s, Leibniz regarded the notions of extension and situation as opposed and *irreducible* to one another. See, for instance, the following passage published in De Risi, *Geometry and Monadology*, 623: 'Ordine meditanti de rebus geometricis ante omnia occurrent duo, Spatium scilicet ipsum absolutum, in quo per se nihil aliud considerari potest quàm extensio; et punctum in quo nihil aliud considerari potest, quàm situs. Spatium non habet situm et punctum non habet extensionem.' Cf. also similar passages from the same years, published in A VI, 4, N. 144, 604–7.

[22] See below, note 103, for a quote.

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Similarly, before 1688 Leibniz endorsed a relational theory of *place* (*locus*) that occasionally he equated with his theory of *situs*. This theory was standard at the time, and Leibniz ascribed it sometimes to Aristotle and other times to Descartes. Newton himself expounded a relational theory of place in the *Principia*, which he complemented with (but did not replace by) a novel theory of absolute place—a theory that Leibniz later fought. A relational theory of place did not require nor imply a relational theory of space, and in his early years Leibniz was simply following mainstream views. In those years, indeed, Leibniz did employ a relational theory of place as a grounding for his relational theory of motion; but after his reading of Newton, who accepted relational place, Leibniz realized that he needed something more—relational *space*.[23]

These different theories of relations—relations of motion, time, and *situs* or *locus*—were developed in the early period of Leibniz's life and may be regarded as the templates on which he molded his new philosophy of space after 1688. Leibniz's theory of space was devised to answer Newton's challenge on motion, and to equip a relational theory of motion with a grounding in the nature of space. The theory was also modeled, as Leibniz himself repeatedly said, on the standardly accepted relational theory of time. Finally, thanks to the hundreds of pages on *geometria situs* that he had written, Leibniz knew that a definition of space as an order of situations was scientifically fruitful and might disclose new perspectives on the foundations of geometry. It would be a mistake, however, to think that Leibniz's relational theory of space was somehow contained in, or entailed by, these previous theories of relations. Leibniz needed a further impulse—Newton's book—to take the last and most important step. It is only because he *did* take this step, that we now regard—in hindsight—those other theories as models and inspirations for the relational theory of space.

Modern interpreters have further been prevented from appreciating Newton's role in the making of Leibniz's theory of space by a series of textual issues.

[23] A clear statement of Leibniz's relationism about place can be found in A VI, 4, N. 367, 2018, from the late 1670s, in which he grounds relational motion in relational place. This text is in fact dependent on Descartes's theory of *locus externus* expounded in *Principles*, II. 13–14 (AT VIIIA 47–8), according to which the place of an object is determined by its relation to other objects arbitrarily taken as points of reference. Later on, Leibniz claimed that Descartes's conception of place is in fact just Aristotle's (A VI, 4, N. 376, 2059); and he himself offered a definition of place that is plainly Aristotelian (A VI, 4, N. 155, 649; from 1685 to 1686). On Newton's conception of absolute place, see note 109, below.

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An important misdirection was caused by the Academy edition of Leibniz's philosophical papers, which published an untitled text of 1677 under the editors' heading *Spatium et motus revera relationes* ('Space and motion are in fact relations').[24] In it, Leibniz does indeed state that motion is relational and then adds that space 'is not a thing' (*res non est*). No more than that, though: nowhere in this text does Leibniz claim that space is relational. The editors' slip is understandable, for all the conceptual reasons expounded above. Yet, this editorial title has misled several authoritative scholars into thinking that Leibniz already endorsed a relational theory of space in 1677.[25]

There were further issues with the main texts needed to establish the connection with Newton. Leibniz consistently claimed only to have read Newton's *Principia* after 1689, namely after the publication of the *Tentamen de motuum coelestium causis*, in which he offered an explanation of the planetary system that was different from Newton's. This dating would not fit with our story, since Leibniz's early statements about the relationality of space are from 1688.[26] In 1991, however, Domenico Bertoloni Meli proved that Leibniz had read Newton's work *before* writing his own essays in natural philosophy, as attested by his handwritten notes on the *Principia* and the drafts of the *Tentamen*.[27] Leibniz's claim of independence was a lie—Newton himself never believed it—and his reading of the *Principia* dated to the fall of 1688.[28]

But the publication of Leibniz's works has also led to the opposite mistake. The text in which Leibniz first advanced a relational theory of space,

[24] A VI, 4, N. 359, 1968. For the complete text, see below, note 78.

[25] See, for instance, R. T. W. Arthur (ed.), *Leibniz: The Labyrinth of the Continuum* [*Labyrinth*] (New Haven: Yale University Press, 2001), 410; Arthur, 'Leibniz's Space', 506; Arthur, *Leibniz*, 130 and esp. 155, where the passage is quoted in such a way as to make it say what it does not; P. Lodge, 'Leibniz on Relativity and the Motion of Bodies', *Philosophical Topics*, 31 (2003), 277–308, at 305, n. 23. Examples could be multiplied.

[26] Leibniz had already stated this in the *Tentamen* itself, GM VI 181; the claim is repeated in subsequent correspondence with Huygens on the same subject (A III, 4, N. 282, 610), as well as in a letter to Mencke (see H. W. Turnbull, J. F. Scott, A. Rupert Hall, L. Tilling [eds.], *The Correspondence of Isaac Newton* [*Newton*] [Cambridge: Cambridge University Press, 1959–77], vol. 3, 3–7).

[27] D. Bertoloni Meli, 'Public Claims, Private Worries: Newton's *Principia* and Leibniz's Theory of Planetary Motion', *Studies in History and Philosophy of Science. Part A*, 22 (1991), 415–49.

[28] Thus Newton referred to Leibniz's essays on physics: 'But Mr. Leibnitz cannot be a Witness in his own Cause. It lies upon him either to prove that he found them before Mr. Newton, or to quit his claim. . . . For the Propositions contained in them (Errors and Trifles excepted) are Mr. Newton's (or easy Corollaries from them) being published by him in other Forms of Words before' (I. Newton, 'An Account of the Book entituled Commercium Epistolicum', *Philosophical Transaction of the Royal Society of London*, 342 [1715], 173–224, at 209). Newton's own annotations on Leibniz's *Tentamen* have been published in Turnbull, *Newton*, vol. 6, 116–22.

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the *Specimen inventorum*, was first published by Carl Immanuel Gerhardt in 1890.[29] This edition of the essay, however, omitted the marginal note in which Leibniz mentioned space, and with some reason: the topic of the note has little to do with the rest of the essay—arguably, Leibniz added it in the margin while distracted by his thoughts on Newton. Gerhardt's edition of the *Specimen inventorum* was (partially) translated into English by G. H. R. Parkinson in 1973 in his influential collection of Leibniz's texts.[30] It was therefore read by many interpreters in this diminished form, without the crucial marginal note. In 1974, Parkinson also published a paper dedicated to the same essay, and in doing so he went back to the manuscript and edited for the first time the marginal note on the relationality of space left out by Gerhardt.[31] Parkinson, however, dated the *Specimen inventorum* to 1686, given the similarity of its content to that of the *Discours de métaphysique* (written in that year). This dating, again, would not fit with our story, since it is a year before the publication of Newton's *Principia*. It was only in 1999 that the Academy published the critical edition of the *Specimen*, showing that it was in fact written on Vienna paper and had therefore to be dated to 1688.[32] The same edition also added a few more fragments dating from 1688–9 and mentioning a relational space, which may be seen as the first elaborations of Leibniz's new theory.

At this point all the pieces of the puzzle were in place, but a certain inertia continued to hold many scholars to an early dating of the *Specimen*. In 2001, Richard Arthur published an important English edition of Leibniz's writings on the continuum, including the *Specimen* and the texts following it, but relied on Parkinson's incorrect dating.[33] Several other scholars doing

[29] GP VII, 309–18.

[30] G. H. R. Parkinson (ed.), *G. W. von Leibniz's Philosophical Writings* [*Leibniz's Writings*] (London: Dent, 1973), 75–86.

[31] G. H. R. Parkinson, 'Science and Metaphysics in Leibniz's "Specimen Inventorum"', *Studia Leibnitiana*, 6 (1974), 1–27.

[32] A VI, 4, N. 312, 1615–30; the marginal note is here in 1621–2. The *Specimen* had already been dated to 1688 in the preprint (*Vorausedition*) of the Academy edition of 1983. I may add that whereas the editorial note of the Academy edition was still marginally doubtful about the dating, this can now be confirmed with certainty. In fact, it seems that the pieces of paper containing Leibniz's notes on Newton and those containing the *Specimen* come from the same large sheet of Viennese paper (or two identical sheets). I thank Siegmund Probst for helping to check anew the paper of the two texts.

[33] See Arthur, *Labyrinth*. The *Specimen* is there edited and translated at 302–33 (Leibniz's marginal note on space is at 312–13), and the other texts at 332–5. They are all dated to 1686. In preparing his edition, Arthur was still working from the text of the *Vorausedition* and acknowledged in a note that the dating of 1688 for the *Specimen* had been suggested (423). Arthur adopted the 1686 dating of the *Specimen* in his important essays on Leibniz's theory of space. See, for instance, R. T. W. Arthur, 'Space and Relativity in Newton and Leibniz', *British Journal*

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